

DIAGNOSIS OF LAMENESS IN DOGS: A PRELIMINARY STUDY

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INTRODUCTION

THE ABILITY TO DIAGNOSE the cause of lameness is essential to both large and small animal clinicians. By observing gait abnormalities it may be possible to identify the site of injury and thus aid in making a diagnosis. Although there are many works on lameness of horses there are few publications which discuss lameness in the dog. Of these, Roy (15) has made the most significant contribution.

Normal locomotion of the dog has been described by various authors. Gait types have been studied by Muybridge (13), Howell (10), Ottaway (14), Lyon (12), Hildebrand (6, 7, 8) and Hollenbeck (9). Gray (5), Barclay (2) and Hutton *et al* (11) have discussed mechanical factors involved in the progression of the dog, while Tokuriki (16, 17) and Adrian *et al* (1) undertook goniometric studies of dog locomotion. Electromyographical studies have been reported by Tokuriki (16, 17).

Lameness and normal gaits of any species can really only be understood with careful observation of the living animal. This paper describes those characteristics of the walk and trot which are particularly useful in the diagnosis of normal and abnormal gaits of the dog.

MATERIALS AND METHODS

Twenty-three medium-sized dogs with clinically normal gaits and eight lame dogs were filmed while walking and trotting. The gaits of four of the lame dogs are described in this paper because these dogs exhibit the characteristics typical of lameness of either the shoulder, stifle or hip. All animals were filmed at 64 and 24 frames per second using a Bolex (16 mm) movie camera loaded with Kodak Tri-X Reversal Film (#7278). Both the lateral and anterior or posterior views of two of the normal dogs were filmed with synchronized

cameras. The completed film sequences were analyzed using a Vanguard Motion Analyzer.¹

The dogs were usually led on a loose lead either to the left or right of the handler, although some trotting sequences were filmed when the animal had no handler. The dogs were filmed in front of a pegboard sheet marked off in one-foot squares. This facilitated comparison of right and left limb movements. As well, other lame dogs presented to the Small Animal Clinic of the Ontario Veterinary College were routinely analyzed in the method to be described.

For each walk and trot gait sequence, the following characteristics were examined: an overall impression of the way the animal moved, head or tail movement and position, arching of the back, symmetry between the contribution of the right and left forelimbs, symmetry between the contributions of the right and left hind limbs and dropping of the forequarters and hindquarters.

RESULTS

Normal Gaits

In locomotion the limbs act synchronously in any one of a variety of patterns each of which is termed a *gait*. Two forms of gait patterns exist: *symmetrical* gaits in which the movement of limbs on one side repeat those of the other side, but half a stride later and *asymmetrical* gaits in which limbs from one side do not repeat those of the other side. The walk, amble, trot and pace are symmetrical gaits while the various forms of the gallop are asymmetrical gaits.

Dogs can exhibit five different types of gaits: the walk, trot, pace, amble and gallop. Of these the walk and trot, and occasionally the pace, were most frequently seen in the clinic as these gaits are used at low speed and are quite stable. The amble, which is essentially a very fast walk (4), is a very difficult gait to maintain and is not commonly used by dogs. The gallop is a gait of high speed in which the animal is supported by one or more limbs or is in suspension during parts of the stride.

The dog initiates locomotion by simultaneously dropping its forequarters and gen-

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¹Vanguard Instrument Co., Melville, New York.

erating propulsion with its hind limbs. The forelimbs recover and the dog stabilizes the pitching movement of the body. This "controlled falling" is found in bipeds, such as human beings, which use gravity to help initiate and maintain locomotion. Quadrupeds such as the dog, however, sustain forward momentum mainly by hind limb and forelimb propulsion. Consequently oscillations of the center of gravity are not pronounced in dogs.

The Walk

The walk (Figure 1) is a slow symmetrical gait in which the left legs perform the same movements as the right, but half a stride later and in which either two, three or sometimes four legs support the animal at any one time (3). A *stride* is here defined as a full cycle of movement of a leg during the support, propulsion and flight phases.

Within a stride, each limb acts for part of the time in a support or stance phase and part in a nonsupport or swing phase (Figures 2A, 2B). In the walk the stance phase is longer in duration than the swing phase and determines the stability of this gait. As speed is increased the duration of the stance phase decreases and that of the swing phase increases.

During the walk, long-legged dogs use ipsilateral leg pairs nearly together in the swing phase and stance phase, while short-legged dogs do not. This type of movement enables long-legged dogs to avoid interference between their limbs. It is of interest to note that only relatively long-legged dogs pace (8).

The forelimbs, which are on the ground as much as 1.5 times longer than the hind limbs (11), act principally to support the body, while the hind limbs act principally to generate forward momentum (10, 16).

Concussion directed through the forelimb in the stance phase passes from the distal to the proximal part of the limb and is lastly absorbed by the synsarcosis which joins this limb to the cranial region of the thorax. The metacarpal pads, followed by the digital pads, are the first structures to absorb concussion. Some dogs who strike the outside or inside of the pad area first appear to have inefficient gaits as some forces generated by the limb are absorbed by excessive joint angulation and rotation.

The shoulder joint exhibits a gradually increasing flexure throughout the stance phase (Figure 2A). The shoulders exert a stabilizing influence on the forequarters and consequently any impairment of their function is reflected by a decrease of that stability.

Little change is observed in the angulation of the elbow joint until the latter part of the

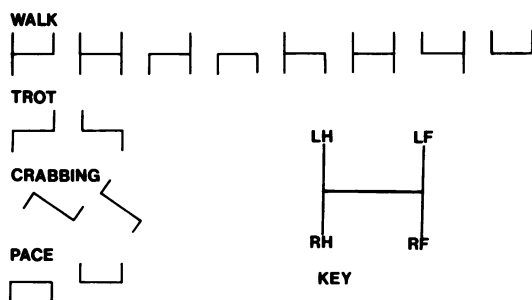


FIGURE 1. Diagrammatic representation of gait sequences used by the dog. In all sequences the dog is assumed to be moving from left to right. The key illustrates an animal with all four limbs on the ground. If a limb is not on the ground the vertical bar representing that limb is removed. The horizontal bar symbolizes the body of the animal. L-left, R-right, F-forelimb, H-hind limb.

stance phase when an extension of this joint occurs concurrent to flexion of the carpal and metacarpophalangeal joints (Figure 2A).

The metacarpophalangeal and carpal joints are in an extended position as the foot pads strike the ground. These joints are hyperextended during the mid-stance phase as the body moves over the forelimb and are flexed in the latter part of the stance phase when the leg is generating forward propulsion (Figure 2A).

In the first half of the swing phase the shoulder joint extends, the elbow and carpal joints flex and the limb is drawn forward and upward (Figure 2B).

In the latter half of the swing phase all joints of the forelimb, notably the carpus and elbow joints, extend until the limb is drawn forward and straightened, thus preparing the limb for the initial impact of the stance phase (Figure 2B).

The concussion of the hind limb is projected into the acetabulum, thus providing a more rigid restriction than that found in the forelimb.

In the walk extension of the hip and tarsal joints occurs throughout the stance phase, but little or no change was observed in the angulation of the stifle joint. Hyperextension of the metatarsophalangeal joint occurs until the latter propulsive part of the stance phase when this joint is flexed. Joint angulation changes in the hind limb are similar to comparable joints of the forelimb. The metatarsophalangeal joint, however, undergoes a more rapid extension during the swing phase than the metacarpophalangeal joint, making it appear as if the anterior part of the pad is raised when contact is made with the ground surface. In com-

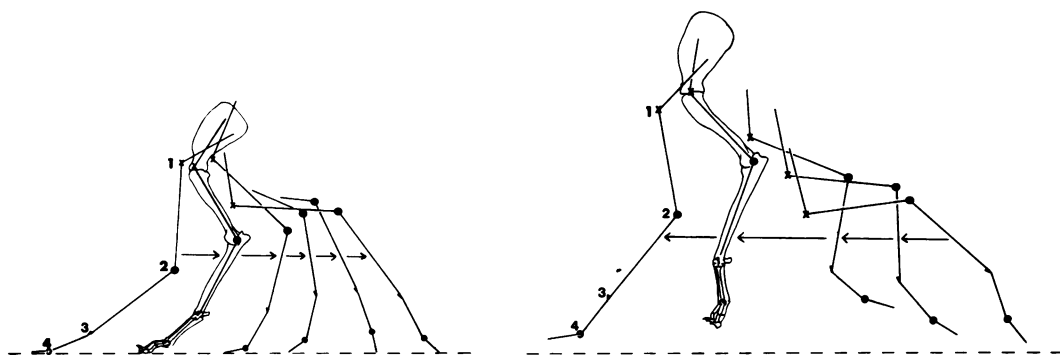


FIGURE 2. Diagram of the goniometric changes of forelimb joints during the stance phase (A) and swing phase (B) of the walk. 1—shoulder joint, 2—elbow joint, 3—carpal joint, 4—metacarpophalangeal joint. The arrow indicates the direction of movement of limb.

parison the pad of the front paw appears to be set more squarely on the ground surface.

The Trot

The trot (Figure 1) is a symmetrical gait of medium speed in which the animal is supported by alternating diagonal pairs of limbs. If there is a period of suspension between the support phases the gait is referred to as a "flying" trot. The trot and flying trot can intergrade within the same gait sequence.

In the trot the forelimbs are free of the ground longer than the hind limbs and allow the front legs to clear the ground in advance of placing the ipsilateral hind limb (8). Long-legged animals are most subject to interference between ipsilateral fore- and hind feet in the trot. Many of these dogs move with their body at an angle to the line of progress, allowing the hind feet to pass beyond the forefeet without interference. This action is termed "crabbing" and is also found in the walk where it may be referred to as "crab walking" (Figure 1). Most, if not all, dogs have asymmetrical contributions from the limbs.

Each joint of the front and hind limbs has the same basic movements as are found in the walk, although their angulations are increased and the stride is of shorter duration (17). Flexure of the stifle in mid-stance of the trot is a notable difference.

In both the walk and trot the tail moves laterally to the side where a hind limb is being placed on the ground. It appears that this movement of the tail may be used to increase the swinging of the hips and therefore increase stride length.

The Pace

The pace (Figure 1) is a symmetrical gait of medium speed in which the animal is sup-

ported by alternating ipsilateral pairs of limbs (4). This is the only symmetrical gait in which there is a pronounced lateral oscillation of the body resulting in significant displacement of the center of gravity. The resulting gait is most stable in long-legged dogs (8) whose leg length dampens the rolling action of the body. Consequently expression of this gait occurs in certain long-legged breeds (Great Dane, German Shepherd, Boxer) although only certain individual animals of these breeds actually do pace.

Abnormal Gaits

Lameness in dogs is manifested in various ways. If one or more limbs do not perform to their average capacity in supporting the dog, the sound limbs must accept increased responsibility of weight-bearing. This results in a shifting of the center of gravity toward the more sound limbs. Oscillations of the center of gravity are usually greater than normal owing to the imbalance caused by lameness.

Shoulder Lameness

(a) Osteochondrosis dissecans — Osteochondrosis dissecans of the left shoulder was diagnosed as the cause of lameness in a St. Bernard dog. This dog overreached with the sound limb and in doing so the forebody was lowered. Because of overreaching, the sound limb remained on the ground for a longer period of time, thus reducing the amount of weight which was placed on the lame left forelimb.

The head was thrown upwards when the lame limb was put on the ground and then dropped when the sound limb bore the weight. The momentum of the upward movement of the head and neck apparently reduces the weight imposed on the lame limb.

The animal was supported for only a short

time on the lame leg and this part of the gait looked uncoordinated and awkward. At a fast walk or trot the animal used the lame leg as a strut and appeared to vault over this limb. There was a compensation by the hind limbs for this forelimb lameness. The hind limbs are placed in a more advanced position than normal, thus dropping the hindquarters and shifting the center of gravity caudally. They, therefore, take more responsibility for support of the animal and reduce the weight directed through the lame leg. The left hind limb was advanced farther than the right.

(b) Fractured scapula — A Greyhound with a healed fracture of the scapula was studied. The same characteristics of lameness were observed in this animal as were observed in the St. Bernard. However, there appeared to be reduced mobility of the left shoulder joint which was compensated by increased angulation changes of the elbow and carpal joints. Head bobbing was particularly noticeable.

Hip Lameness

The example studied was a St. Bernard suffering from bilateral hip dysplasia. Radiographic examination had indicated that dysplasia was worse in the right hip.

There was an obvious disharmony in the hind limb action, with both hind limbs having a short and uncoordinated step. This was particularly true of the right hind limb.

The forelimbs overreached and resulted in a dropping of the forebody. Also, the head was held steady at a lower position than normal. Both these compensations shifted the center of gravity forward and reduced the weight being borne by the hind limbs.

Stifle Lameness

Lameness in the left stifle was observed in a German Shepherd suffering from a ruptured cruciate ligament. The lame leg showed decreased flexion and extension of all joints and the right hind leg was placed further forward than normal. Consequently the dog dropped its hindquarters while the sound right hind leg was on the ground. It appeared as if the uninjured right hind limb was attempting to take the weight off the lame limb. As well, there was a greater stride length of both forelimbs which, by extending farther caudally than normal in the stance phase, also removed some of the weight which would normally pass through the lame left leg.

This dog also used the momentum of its tail to reduce the weight on the left hind limb. The tail was lifted when the lame leg was on the ground and dropped when the good leg

was on the ground. As well, the back was arched when the lame leg was on the ground.

DISCUSSION

The diagnosis of normal gaits and lameness in a dog should be carried out by observing the animal from the lateral, cranial and caudal views. A general impression of the locomotion is first gained in order to note if there is a stilted or uneven gait. Characteristics of normal gaits of dogs are predictable within limits but variations with size, breed (6) and possibly sex and age are present.

Next, the head should be observed for any up-and-down movement that would indicate a forelimb lameness. The movements of the forelimbs should be compared to see if there is asymmetry in the angulation changes of these two limbs. Even though asymmetry does exist in the action of the fore- and hind limb pairs, this imbalance is usually not noticed in a normal dog. It must be remembered, however, that the forelimbs may act asynchronously to adapt for a hind limb lameness and vice versa.

The function of the fore- and hind limbs are quite different and comparison should not be made between them. In locomotion the front legs act principally to arrest, while the hind limbs act to generate forward momentum of the body (16) although all limbs are used in both acceleration and deceleration. The hind limbs produce the propelling force earlier in their stance phase than to the forelimbs (16) and are used in deceleration more than the forelegs are used in acceleration (11). At the moment of contact the hind limbs are placed more medially than the forelimbs allowing for an effective propulsion force to be exerted by the hind limbs. The more lateral placement of the forelimbs stabilizes the decelerative action of the forebody.

The well-muscled shoulder region provides the main propulsive effort required to move the forelimb and to absorb the concussion directed through the limb. Approximately 60% of a dog's static weight is supported by the front limbs (15) and during walking the maximum vertical force exerted by the forelimbs is 60% of the total reaction against the ground (2, 6). Injury to shoulder structures would result in a decrease in ability to swing the limb in its normal arc and also to absorb the weight of the animal during the stance phase.

Observe to see if the animal is overreaching with either or both of the forelimbs, thereby dropping the forequarters, and if the head is carried in a lower position than normal. Both

of these behaviors would indicate a hind limb lameness. Observe the back to see if it is arched; dogs with hind limb lameness sometimes attempt to shift the center of gravity forward by arching the back. The movements of the hind limbs should be compared to see if they contribute unequally to the gait. Special note should be taken of a decrease in stride length by the hind legs such as would be present with a hip impairment. Since decelerative and accelerative forces generated lower down each hind limb are transmitted to the body via the hip joint lameness in the hip will effect the total range of motion of the hind legs.

Movement of the tail is a behavior which may be of use in diagnosis of hind limb lameness. Observe the direction (side to side, up and down) the tail is moving, especially in the trot. A dog which moves its tail up and down is usually, but not always, suffering from a hind limb lameness.

"Crabbing" may also be an important diagnostic tool. If the animal is crabbing so that its hindquarters are shifted to the left (crabbing left) (Figure 1), its right hind and left forelimbs will be the limbs which will take prime responsibility for propulsion because they lie closer to the line of action of the body. An animal which has injured either its left hind or right foreleg will crab left to reduce the responsibility of these limbs to locomotion. Also, an animal which has injured its right hind or left foreleg will crab right. Crabbing does not imply that the animal is necessarily lame because most dogs crab, but it is a behavior used by the dog for taking the weight off a lame leg.

Another important aspect of gait is acceleration of an animal from a sitting or standing position. It is especially important to observe use of the limbs in acceleration before the animal has "warmed up." Dogs which are lame in the right hind leg, for example, will accelerate using the left hind leg. This limb will remain on the ground the longest period of time of either hind limb. As well, a forelimb which remains on the ground for the longest period of time during acceleration may indicate a lameness in the opposite forelimb.

Further work needs to be done on lameness in dogs. It is still not known, for example, how a lameness in the proximal region of a limb differs from that found more distally in the limb. As well, more study is required to determine the effect of injury to more than one limb and of different disease and injury states on the locomotion of an animal. Study of lameness in quadrupedal animals must attempt to

adopt the more advanced techniques used by researchers of locomotion in human beings before a more thorough understanding of lameness can be realized.

SUMMARY

Lameness in the dog is typified by a shift of weight to the sound limbs. If there is a unilateral lameness in either the front or hind limbs, there is a dropping of the body when the sound limb is placed on the ground and an elevation of the body when the lame limb is placed on the ground.

Forelimb lameness is characterized by head bobbing. The head is raised when the lame leg is on the ground and dropped when the sound limb is supporting the body.

Hind limb lameness is characterized by a dropping of the forequarters as a result of overreaching by both forelimbs and by maintaining the head at a lower position than normal. Some breeds raise their tails when a lame hind limb is on the ground and drop it when the sound limb is on the ground.

When examining the dog for lameness the clinician should consider the following characteristics: 1) fluidity and coordination of movement, 2) head and tail movement and position, 3) asymmetry between the contribution of the right and left front and hind limbs, 4) dropping of the fore- or hindquarters and 5) arching of the back. Using these criteria it should be possible to identify the limb which is injured.

RÉSUMÉ

Chez le chien, une boiterie se caractérise par le transfert du poids corporel sur les membres sains. Lorsqu'il existe une boiterie unilatérale antérieure ou postérieure, il se produit un abaissement du corps lorsque le membre sain s'appuie sur le sol et une élévation du corps lorsque le membre malade s'appuie sur le sol.

Une boiterie d'un membre antérieur se caractérise par des mouvements de la tête de bas en haut et de haut en bas. L'animal lève la tête quand le membre boiteux repose sur le sol et il la baisse quand le membre sain supporte le poids du corps.

Une boiterie d'un membre postérieur se caractérise par un abaissement des quartiers antérieurs, parce que les membres antérieurs s'appuient sur le sol plus en avant que normalement, et par un port de tête plus bas que normalement. Les sujets de certaines races se lèvent la queue quand un membre postérieur

boiteux s'appuie sur le sol; ils la baissent quand le membre postérieur sain s'appuie sur le sol.

Lors de l'examen d'un chien boiteux, le clinicien devrait tenir compte des critères suivants: 1) la facilité et la coordination des mouvements, 2) les mouvements et les positions de la tête et de la queue, 3) l'asymétrie entre les mouvements des membres droits et gauches, antérieurs et postérieurs, 4) l'abaissement des quartiers antérieurs ou postérieurs, 5) l'apparence voûtée du dos. Avec l'aide de ces critères, il devrait être possible d'identifier le membre lésé.

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